Color of berry and juice of 'Isabel' grape treated with abscisic acid in different ripening stages

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Abstract – The objective of this work was to evaluate the effect of (*S*)-cis-abscisic acid (*S*-ABA) application at different ripening stages, in increasing phenolic compounds and color of berry and juice of 'Isabel' grape (*Vitis labrusca*). The evaluated treatments were: control, without *S*-ABA application; 400 mg L^{-1} *S*-ABA applied 7 days before veraison (DBV) + 400 mg L^{-1} *S*-ABA at 35 days after first application (DAFA); 400 mg L^{-1} *S*-ABA applied at veraison (V) + 400 mg L^{-1} *S*-ABA at 35 DAFA; and 400 mg L^{-1} *S*-ABA applied 7 days after veraison (DAV) + 400 mg L^{-1} *S*-ABA at 35 DAFA. There was no difference among treatments regarding the physical characteristics of berries and clusters, as well as total polyphenols in berry and juice. However, there was an increase in total anthocyanins in berry and juice with *S*-ABA application. Colorimetric variables indicated the increase in color of berry treated with *S*-ABA. Juices produced from grapes treated with *S*-ABA were more appreciated by tasters. The treatments with 400 mg L^{-1} *S*-ABA applied 7 days before, during, or 7 days after veraison, combined with an additional application 35 days after the first one, increment total anthocyanin concentration and color of berry and juice of 'Isabel' grape, with better juice acceptance, without affecting total polyphenol concentration.

Index terms: *Vitis labrusca*, anthocyanins, color, growth regulador.

Cor das bagas e do suco da uva 'Isabel' tratada com ácido abscísico em diferentes fases de maturação

Resumo – O objetivo deste trabalho foi avaliar o efeito da aplicação do (*S*)-cis-ácido abscísico (*S*-ABA) em diferentes fases de maturação, no incremento de compostos fenólicos e na cor das bagas e do suco de uva 'Isabel' (*Vitis labrusca*). Os tratamentos avaliados foram: testemunha, sem aplicação de *S*-ABA; 400 mg L^{-1} de *S*-ABA aplicados 7 dias antes do “véraison” (DAV) + 400 mg L^{-1} de *S*-ABA aos 35 dias após a primeira aplicação (DAPA); 400 mg L^{-1} de *S*-ABA aplicados no “véraison” (V) + 400 mg L^{-1} de *S*-ABA aos 35 DAPA; e 400 mg L^{-1} de *S*-ABA aplicados 7 dias após o “véraison” (DAV) + 400 mg L^{-1} de *S*-ABA aos 35 DAPA. Não houve diferença entre os tratamentos para as características físicas das bagas e dos cachos, bem como para os compostos fenólicos totais das bagas e do suco. Contudo, houve incremento de antocianinas totais da baga e do suco com a aplicação de *S*-ABA. As variáveis colorimétricas indicaram aumento da cor das bagas quando estas foram tratadas com *S*-ABA. Os sucos elaborados com uvas tratadas com *S*-ABA foram mais apreciados pelos provadores. Os tratamentos com 400 mg L^{-1} de *S*-ABA aplicados 7 dias antes, durante ou 7 dias após o “véraison”, associados à uma segunda aplicação 35 dias após a primeira, promovem o incremento da concentração de antocianinas totais e da intensidade da cor das bagas e do suco da uva 'Isabel', com melhor aceitação do suco, sem afetar a concentração de polifenóis totais.

Termos para indexação: *Vitis labrusca*, antocianinas, cor, regulador de crescimento.

Introduction

Vitis labrusca cultivars and their hybrids are the main grapes for processing in Brazil. In this context, 'Isabel' grape is the most widely cultivated and represents approximately 48% of processed grapes. Despite being vigorous, easy to grow, productive, and having a high potential for sugar accumulation, ranging from 15 to 19ºBrix, its juice requires blending with rich colored cultivars to improve color attributes (Rizzon & Meneguzzo, 2007; Ritschel & Sebben, 2010; Mello & Machado, 2015).

The color of the grape juice significantly affects product acceptability and is used as a quality indicator,

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which emphasizes the importance of developing products with attractive appearance for the food industry (Araújo, 2011; Roberto et al., 2013). Borges et al. (2011) and Maia et al. (2013) recommend blending 'Isabel Precoce' and 'Isabel' grape juice with a color-rich cultivar, in order to improve juice color.

In grapes, anthocyanins, which are phenolic compounds responsible for color, are mainly located in the skin and can also be found in the pulp of some cultivars rich in color. These compounds accumulate during ripening, and abscisic acid (ABA) is reported as being responsible for their biosynthesis (Ban et al., 2003; Owen et al., 2009; Koyama et al., 2010).

Several studies have shown that the exogenous application of ABA enhances the color of 'Pinot Noir', 'Redglobe', 'Crimson Seedless', 'Merlot', 'Cabernet Sauvignon', 'Rubi', and 'Benitaka' grapes (Mori et al., 2005; Peppi et al., 2007a, 2007b; Owen et al., 2009; Koyama et al., 2010; Deis et al., 2011; Roberto et al., 2012, 2013; Yamamoto et al., 2015). In 'Isabel' grape, a significant increase was observed in anthocyanin concentration in berries and whole juice by the exogenous application of 400 mg L^{-1} of the isomer (*S*)-cis-abscisic acid (*S*-ABA) at veraison (Koyama et al., 2014a); however, the optimal maturation phase of grapes in which to apply this growth regulator has not been determined so far, which may influence its effectiveness.

Therefore, it is necessary to identify *S*-ABA efficiency in 'Isabel' grape when applied in a wider space of time during ripening, i.e., before, during, and after veraison, since the size of the area to be treated and weather conditions can affect the ideal period for the application of the growth regulator.

The objective of this work was to evaluate the effect of (*S*)-cis-abscisic acid (*S*-ABA) application at different ripening stages, to increase phenolic compounds and color of berry and juice of 'Isabel' grape (*Vitis labrusca*).

Materials and Methods

The study was conducted in a 11-year-old commercial vineyard of own-rooted 'Isabel' grapes (*Vitis labrusca* L.) belonging to Intervin winery, located in the municipality of Maringá, in the state of Paraná, Brazil (23°25'S, 51°57'W, at an altitude of 542 m). According to Köppen’s classification, the climate of the region is Cfa, i.e., subtropical with average temperature in the coldest month below 18°C and average temperature in the warmest month above 22°C. The average annual rainfall is 1,596 mm, with a tendency of concentrated rainfall in the summer.

The vines were trained on overhead trellises with 65 spurs per plant and spaced 4.0x1.0 m apart. Pruning was performed to leave 2–3 buds per spur, then 5% hydrogen cyanamide was applied to the buds to induce and standardize sprouting. During the trials, the standard regional cultivation practices with regard to nutrition, weed control, and pest and disease management were adopted.

The effect of *S*-ABA application on grapes at different ripening stages was assessed during two consecutive crop years: regular season in December 2011 and out of season in May 2012. *S*-ABA, at an active concentration of 100 g L^{-1}, was supplied by Valent BioSciences Corporation (Libertyville, IL, USA).

The evaluated treatments were: control, without *S*-ABA application; 400 mg L^{-1} *S*-ABA applied 7 days before veraison (DBV) + 400 mg L^{-1} *S*-ABA at 35 days after first application (DAFA); 400 mg L^{-1} *S*-ABA applied at veraison (V) + 400 mg L^{-1} *S*-ABA at 35 DAFA; and 400 mg L^{-1} *S*-ABA applied 7 days after veraison (DAV) + 400 mg L^{-1} *S*-ABA at 35 DAFA. Veraison of 'Isabel' grape was defined as the moment when approximately 50% of the berries began to change color and soften (Baggiolini, 1952; Baillod & Baggiolini, 1993).

The experimental design was a randomized complete block with four treatments and five replicates, with five vines per plot. Fifteen representative clusters in each plot were marked before the application of treatments for further evaluation.

For treatment applications, clusters were sprayed in the morning using a knapsack sprayer at a pressure of 568.93 psi (39.22 bar), with JA1 hollow cone nozzle tips at a volume of 800 L ha^{-1} to provide complete and uniform coverage. In addition, 0.3 mL L^{-1} of Break-Thru (Evonik Industries AG, Essen, Germany) nonionic surfactant was added to all treatments.

In both crop seasons, clusters of each plot were manually harvested when the berries presented the following chemical values for total soluble solids (TSS, as ºBrix), titratable acidity as tartaric acid (TA, in percentage of w/v), TSS/TA ratio, and pH: 15.5, 0.4, 37.7, and 3.16 for the control treatment; 15.6, 0.4, 40.9, and 3.19 for 7 DBV + 35 DAFA; 15.6, 0.4, 40, and 3.21 for V + 35 DAFA; and 15.6, 0.4, 40.2, and 3.14 for 7 DAV + 35 DAFA. For each plot, 90 berries were collected for physicochemical analysis, with two berries taken from the upper, middle, and bottom regions of each marked cluster.

The physical characteristics of grapes were evaluated by determining the mass (g) and diameter (mm) of berries, as well as the weight (g) and length (cm) of clusters, using a scale and a digital caliper.

Berry color was analyzed using the CR-10 Konica-Minolta colorimeter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ, USA), to obtain the following variables from the equatorial portion of berries (n=2 per berry): lightness, chroma, and hue (Cantín et al., 2007). Lightness (L*) values may range from 0 (black) to 100 (white). Chroma (C*) indicates the purity or intensity of a color, i.e., the distance from gray (achromatic) toward a pure chromatic color, and is calculated from the a* and b* values of the CIELab scale system, which begins at zero, for completely neutral colors, and has no arbitrary end, but increases in intensity with magnitude. Hue (hº) refers to the color wheel and is measured in angles, in which green, yellow, and red correspond to 180º, 90º, and 0º, respectively (MacGuire, 1992; Lancaster et al., 1997; Peppi et al., 2006).

Whole grape juices from treatment plots were produced by the Welch process (not from concentrate grape juice), which consists of extracting the juice by steam entrainment using a stainless steel steam juicer pot, with a 7.0-kg capacity, model PSM-07 C/F, (Hauber Macanuda, Joinville, SC, Brazil), without any added enzyme (Rizzon & Link, 2006). For this extraction, a sample of 4.0 kg of clusters from each plot was used, producing an average of 2.0 L whole juice. At first, the bottom section of the steam juicer pot was filled with water and the heat was turned on high. Washed grape samples (4.0 kg) were placed in the top section of the juicer, the basket was filled all the way to the top, and the lid was put on. After 45 min, all grape juice was drained into the middle section of the juicer and then bottled at warm temperature (75°C) into 1.0-L capacity sterilized polyethylene containers with lids. After cooling, juice bottles were stored in the refrigerator, at 4°C, for further anthocyanin and polyphenol analyses.

The concentration of total anthocyanins in berries and juices of all treatments were determined according to Clemente & Galli (2013). For total anthocyanin extraction, 30 berries were homogenized in a blender, and 50 g of this mixture or 50 mL of juice were used for quantification. Samples were macerated and homogenized with 150 mL extracting solution (70 mL ethanol 70% and 30 mL HCl 0.1%, pH 2.0) for 2 min in a blender, placed in a beaker covered with parafilm and aluminum foil, and then extracted in darkness for 12 hours at 4ºC. Afterwards, a filtration was made and 100 mL of this solution were mixed with 100 mL extracting solution. An aliquot of 2.0 mL was taken from the stock solution and completed to 100 mL with the extracting solution, then left at room temperature in darkness for 2 hours. The extracting solution was used as a blank. The absorbance of each sample from berries and juices was determined at 535 nm using a spectrophotometer Genesys 10S UV-Vis, (Thermo Scientific Fisher Inc., Waltham, MA, USA). Readings were expressed as milligrams of total anthocyanins as malvidin-3-glucoside per 100 g berries (mg 100 g^{-1}) and per liter of juice (mg L^{-1}).

The concentration of total polyphenols in berries and juices was determined by the Folin-Ciocalteu spectrophotometric method (Bucic-Kojic et al., 2007). For total polyphenol extraction from berries, samples of 30 berries per plot were macerated and 5.0 g were homogenized with 50 mL ethanol 50% in a blender during 2 min, then centrifuged at 3,500 rpm during 5 min. An aliquot of 0.2 mL of the extract was mixed with 1.8 mL distilled water and 10 mL of 10-fold diluted Folin-Ciocalteu reagent. After 30 s to 8 min, 8.0 mL of 7.5% Na_2CO_3 solution was added. All test tubes with the mixture were shaken for 10 s on the vortex and kept in darkness during 2 hours. For total polyphenol extraction from grape juices, samples of 5.0 mL whole juice per plot were used. The absorbance of each sample from berries and juices was measured after 15 min, at 765 nm, using a spectrophotometer Genesys 10S UV-Vis, (Thermo Scientific Fisher Inc., Waltham, MA, USA) against a blank sample. The blank sample was prepared with water instead of with the extract. Total polyphenol was calculated from the calibration curve obtained with gallic acid. Readings were expressed as mg 100 g^{-1} berries and g L^{-1} juice (gallic acid equivalents).

Sensory analysis of grape juice was performed adopting a randomized complete block design, with 70 untrained tasters. Evaluations were performed in individual booths with special daylight lighting in the laboratory for sensory analysis. The color, aroma, flavor, body, and consumer acceptance of the juice samples were evaluated using a 9-point hedonic scale, which ranged from: 1, dislike extremely, to 9, like extremely (Villanueva et al., 2005). Samples (40 mL each) were served at 4ºC in transparent acrylic glasses. Each taster received samples from the four treatments, coded with random three-digit numbers in randomized order. Drinking water at room temperature was served to the tasters for mouth cleaning before and between evaluations of grape juice samples.

Means were subjected to the analysis of variance and compared using Duncan's test, at 5% probability. Since the results observed for each crop season were similar, means of the combined crops were considered for discussion (Koyama et al., 2014a).

Results and Discussion

There was no difference in relation to *S*-ABA application at different ripening stages for physical characteristics, such as mass and diameter of berries and mass and width of clusters (Table 1). It can be inferred that the application of this growth regulator does not affect the physical characteristics related to the productivity of 'Isabel' grape. Similar results were reported by Koyama et al. (2014a, 2014b), who studied the effects of different concentrations and frequencies of *S*-ABA application at veraison on the same cultivar.

Table 1. Average mass and diameter of berries and mass and length of clusters, for the 2011 and 2012 crop seasons, of 'Isabel' grapes (*Vitis labrusca*) subjected to different treatments with (*S*)-cis-abscisic acid (*S*-ABA).

Treatments(1) (400 mg L^{-1} *S*-ABA)	Mass of berries (g)	Diameter of berries (mm)	Mass of clusters (g)	Length of clusters (cm)
Control	3.0±0.3	15.8±0.2	101.6±3.7	10.5±0.1
7 DBV + 35 DAFA	3.1±0.2	15.7±0.5	99.2±3.8	10.5±0.3
V + 35 DAFA	2.9±0.1	15.4±0.3	99.6±3.7	10.5±0.3
7 DAV + 35 DAFA	3.1±0.2	15.9±0.2	99.4±3.9	10.7±0.1
F	1.04^{ns}	0.96^{ns}	0.46^{ns}	0.47^{ns}
CV (%)	8.44	2.89	7.07	2.41

(1)Control, without *S*-ABA application; 7 DBV, 400 mg L^{-1} *S*-ABA applied 7 days before veraison; V, 400 mg L^{-1} *S*-ABA applied at veraison; 7 DAV, 400 mg L^{-1} *S*-ABA applied 7 days after veraison; and 35 DAFA, 400 mg L^{-1} *S*-ABA applied 35 days after the first application. ^{ns}Nonsignificant.

The application of ABA did not affect the physical characteristics of other cultivars, including Benitaka, Rubi, and Cabernet Sauvignon (Koyama et al., 2010; Roberto et al., 2012, 2013). In contrast, for 'Flame Seedless' and 'Redglobe' grapes, in some evaluated crops, there was an increase in berry mass with the application of *S*-ABA (Peppi et al., 2006, 2007a). These variations suggest that *S*-ABA does not affect the physical characteristics of berries, such as mass and length, which can be more influenced by the weather conditions of a specific season.

However, *S*-ABA application increased anthocyanin concentration in berries and whole juice of 'Isabel' grape, except in berries that received application at veraison, which showed similar results to the control (Table 2). When studying *S*-ABA application at veraison to 'Isabel' grape, Koyama et al. (2014a) observed a different relationship for the increment in anthocyanin concentration in berries in the juice, with the application of 200 and 400 mg L^{-1} *S*-ABA, independently of the application frequency. In contrast, for whole juice, the concentration of 400 mg L^{-1} applied once or twice was more effective.

Green berries are the tissues most responsive to ABA, when compared to more ripe berries; therefore, it is essential to determine the time for the completion of the treatment with the growth regulator. This suggests that the reception or the mechanism of the signal for ABA is modulated by grape development (Giribaldi et al., 2010), since the ABA level in the skin increases at the beginning of ripening up to 20 days and reduces until harvest (Berli et al., 2011). However, at veraison, ABA reaches its peak and, at this moment, cannot interfere in its synthesis (Davies & Böttcher, 2009; Giribaldi et al., 2010).

Other studies also suggest that the optimal application timing of *S*-ABA varies according to the cultivar and can be effective even after veraison, as reported for the 'Redglobe' (Peppi et al., 2007a) and 'Crimson Seedless' Table grapes (Peppi et al., 2007b), for which the best time of application was at veraison. For 'Isabel' grape, however, the present study showed that the application of *S*-ABA can be performed at a wider interval of time, that is, before, during, and after veraison, aiming to increase anthocyanins in berries and in whole juice. It should be noted, however, that in this study, a second application was performed on the same day, at 35 DAFA, in all treatments, which can be standardized in some way by the observed results. Therefore, it remains to be elucidated whether one application at a particular developmental stage is sufficient to increase anthocyanin concentration in 'Isabel' grape, considering that, for some cultivars, such as Redglobe, a single application of *S*-ABA is sufficient (Peppi et al., 2007a), whereas for 'Benitaka' and 'Rubi', two applications of *S*-ABA are required to enhance significantly the color of berries (Roberto et al., 2012, 2013). Even though these authors did not study anthocyanin concentration in berries, it probably was also higher in these conditions, since color is related to its concentration.

The increase in anthocyanin concentration with ABA application was also observed in berries, skin, pulp, and juice in experiments with 'Isabel', 'Cabernet Sauvignon', 'Pinot Noir', and 'Merlot' grapes (Mori et al., 2005; Owen et al., 2009; Koyama et al., 2010, 2014a; Deis et al., 2011; Giribaldi et al., 2010). However, besides varying according to the cultivar, the increment in anthocyanin concentration with the application of ABA is also affected by weather conditions, since the increase in anthocyanin concentration was not observed in some crops, as in Table grapes, such as 'Redglobe' (Peppi et al., 2007a) and 'Crimson Seedless' (Peppi et al., 2007b).

Regarding total polyphenol concentration, there was no difference between application timing on berries and whole juice of 'Isabel' grape (Table 2). Koyama et al. (2014a) also found that the application of *S*-ABA did not alter total polyphenol concentration in 'Isabel' berries, but there was an increment in juice, independently of the concentration and timing of the application. However, in 'Malbec' (Berli et al., 2011) and 'Cabernet Sauvignon' grapes (Deis et al., 2011) treated with ABA, there was an increase in total polyphenol in berries.

The concentration of phenolic compounds can vary in commercial and reconstituted grape juices, indicating the effect of the cultivar, region, processing and cultural practices adopted (Malacrida & Motta, 2005; Vargas et al., 2008). In addition, because it is a set of various compounds, the results observed for polyphenols and anthocyanins in a particular treatment do not show the same relationship.

Regarding variables related to berry color, L* was lower in grapes that received *S*-ABA application when compared to the control, which means a darker skin color (Table 3). The same was observed for C*, indicating a pure color. For the variable h°, no statistic difference was found between treatments. In 'Isabel' grape treated with *S*-ABA, Koyama et al. (2014a) also obtained similar results.

The application of *S*-ABA can frequently reduce the means of L*, not alter h°, and reduce C* in some crops of 'Rubi' and 'Benitaka' grapes (Roberto et al., 2012, 2013). However, timing of application can vary according to the cultivar and growing region (Peppi et al., 2007a, 2007b; Ferrara et al., 2013). As noted for anthocyanin concentration, independently of application timing, there was an improvement in the color of 'Isabel' grape berries treated with *S*-ABA (Table 3), showing the relationship between the results obtained for these variables.

Table 2. Average total anthocyanins and polyphenols in berries and whole juice, for the 2011 and 2012 crop seasons, of 'Isabel' grapes (*Vitis labrusca*) subjected to different treatments with (*S*)-cis-abscisic acid (*S*-ABA)(1).

Treatments(2) (400 mg L^{-1} *S*-ABA)	Total anthocyanins in berries (mg 100 g^{-1})	Total anthocyanins in juice (mg L^{-1})	Total polyphenols in berries (mg 100 g^{-1})	Total polyphenols in juice (mg L^{-1})
Control	9.6±1.7b	56.8±4.5b	27.2±2.3	2.7±0.1
7 DBV + 35 DAFA	14.2±1.8a	69.9±5.4a	28.2±2.0	2.8±0.2
V + 35 DAFA	12.0±1.0ab	76.4±6.0a	28.2±1.3	2.9±0.3
7 DAV + 35 DAFA	13.1±2.7a	70.7±13.1a	29.6±3.3	3.0±0.3
F	3.84*	4.32*	0.50^{ns}	0.93^{ns}
CV (%)	18.33	13.04	10.86	13.11

(1)Means within columns followed by different letters differ significantly by Duncan's test, at 5% probability. (2)Control, without *S*-ABA application; 7 DBV, 400 mg L^{-1} *S*-ABA applied 7 days before veraison; V, 400 mg L^{-1} *S*-ABA applied at veraison; 7 DAV, 400 mg L^{-1} *S*-ABA applied 7 days after veraison; and 35 DAFA, 400 mg L^{-1} *S*-ABA applied 35 days after the first application. nsNonsignificant. *Significant at 5% of probability.

For sensory analysis of juices, there were differences for all attributes except for aroma (Figure 1). Regarding juice color, the preference was for all juices whose grapes were treated with *S*-ABA, especially those that received the application at veraison and 7 days later. These results indicate that the treatments resulted in an increase in anthocyanin concentration and, consequently, in juice color, changing the visual quality as to be perceptible to the evaluators. In sensory analysis performed by Pontes et al. (2010) with commercial grape juices, products with higher intensity of sensory attributes and that presented balance between them had greater acceptance.

Table 3. Average lightness (L*), chroma (C*), and hue angle (h°), for the 2011 and 2012 crop seasons, of 'Isabel' berries (*Vitis labrusca*) subjected to different treatments with (S)-cis-absisic acid (*S*-ABA)$^{(1)}$.

Treatments$^{(2)}$ (400 mg L^{-1} *S*-ABA)	L*	C*	h°
Control	27.7±0.6a	4.1±0.7a	106.3±17.1
7 DBV + 35 DAFA	24.9±0.2b	2.1±0.1b	124.1±4.2
V + 35 DAFA	24.8±0.3b	2.1±0.2b	116.9±10.4
7 DAV + 35 DAFA	25.1±0.2b	2.0±0.1b	126.0±7.0
F	54.39*	27.23*	1.81^{ns}
CV (%)	1.64	16.98	12.53

$^{(1)}$ Means within columns followed by different letters differ significantly by Duncan's test, at 5% probability. $^{(2)}$Control, without *S*-ABA application; 7 DBV, 400 mg L^{-1} *S*-ABA applied 7 days before veraison; V, 400 mg L^{-1} *S*-ABA applied at veraison; 7 DAV, 400 mg L^{-1} *S*-ABA applied 7 days after veraison; and 35 DAFA, 400 mg L^{-1} *S*-ABA applied 35 days after the first application. ^{ns}Nonsignificant. *Significant at 5% of probability.

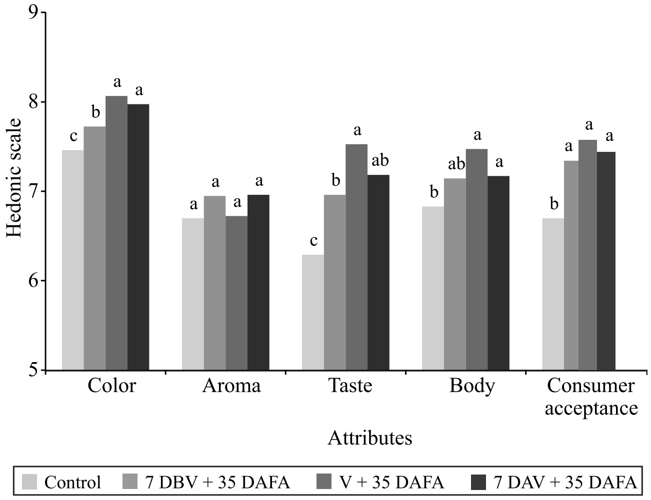

Figure 1. Nine-point hedonic scale for color, aroma, taste, body, and consumer acceptance of 'Isabel' (*Vitis labrusca*) whole juice, with grapes subjected to different treatments with 400 mg L^{-1} (*S*)-cis-abscisic acid (*S*-ABA). The scale ranges from: 1, dislike extremely, to 9, like extremely. Average of the 2011 and 2012 crop seasons. Means within bars followed by different letters differ significantly by Duncan's test, at 5% probability. Control, without *S*-ABA application; 7 DBV, 400 mg L^{-1} *S*-ABA applied 7 days before veraison; V, 400 mg L^{-1} *S*-ABA applied at veraison; 7 DAV, 400 mg L^{-1} *S*-ABA applied 7 days after veraison; and 35 DAFA, 400 mg L^{-1} *S*-ABA applied 35 days after the first application.

Borges et al. (2011) and Maia et al. (2013), in a study with 'Isabel Precoce' and 'Isabel' grapes, respectively, recommended blending their juices with other cultivars, in order to improve color and taste balance. Despite this, given the predominance of 'Isabel' grape production in the main juice-producing regions and the fact that the Brazilian consumer's palate is accustomed to the juice of this cultivar, it is unlikely that, at first, the grape agro-industries will use large volumes of the other cultivars as juice feedstock (Borges et al., 2011). However, sensory analysis shows that the use of the *S*-ABA growth regulator can be a solution to the lack of color of 'Isabel' grape and can supply the need for blending with other cultivars.

The application of *S*-ABA, besides improving the color of 'Isabel' whole juice, also affected positively the other attributes of sensory analysis, as observed by Koyama et al. (2014a), who assessed the juice of this same cultivar treated with *S*-ABA. For flavor, juices from treated berries received superior scores when compared to the control, with no difference between treatments with the application before or after veraison. These juices also showed higher scores for body and consumer acceptance, although, for body, no difference was found between the control and the application before veraison.

Therefore, the application of 400 mg L^{-1} *S*-ABA before, during, or after veraison does not alter the physical characteristics of clusters and berries. However, it increases anthocyanin concentration in berries and whole juice of 'Isabel' grape, as well as the color variables of berries, independently of the timing of application, without changing the concentration of total polyphenols and also producing juices that are more appreciated in sensory analysis. The obtained results are an indicative that *S*-ABA can be applied in a wider space of time, around veraison, resulting in grapes as a source of raw material for a more deeply-colored juice.

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Conclusion

The treatments with 400 mg L^{-1} (*S*)-cis-abscisic acid (*S*-ABA) applied 7 days before, during, or 7 days after veraison, combined with an additional application 35 days after the first one, increment total anthocyanin concentration and color of berry and juice of 'Isabel' grape, with better juice acceptance, without affecting total polyphenol concentration.

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